§5. Two Dimensional Ion Temperature and Velocity Measurements by Use of Visible Light Tomography System and Super SINET

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For the past four years, we have been developing a new visible-light tomography system for two dimensional (2-D) measurements of ion temperature and velocity. It is now is used for TS-4 device, and will be for LHD together with a well-controlled compact toroid (CT) injection system and the Super SINET. The coaxial plasma gun will deposit impurity plasma at an arbitrary spatial position of the Large Helical Device (LHD) plasma at an arbitrary time. Its injection time is much shorter than the conventional pellet injection, leading us to a new fast particle diffusion measurement in MHD time scale. The 2-D visible light tomography system was designed to measure directly 2-D profiles of its ion diffusion, temperature and velocity.

In 2004, the Super SINET system was installed for the visible light tomography diagnostics that will be used by both groups of LHD and TS-4. The tomography diagnostics is composed of 120 channel optical fibers and three polychromators with three ICCD cameras. Its major problem is that the measured Doppler shift and width for ion velocity and temperature measurements are integrated along the viewing line. The conventional reconstruction for the local date is to solve the inverse problem at each wave length and to fit a Gausian profile to the obtained local spectrum.. However, the reconstructed local data have no relation with each other, though their spectrum are close to the Gausian profile, so that we observed a significant increase in S/N ratio especially around the tail (short and long wavelength) regime of line spectrum.

We demonstrated for the first time, a new spectrum reconstruction method based on assumptions of Gausian profile of line spectrum. Unlike the conventional MEM (Maximum Entropy Method) tomography only for the spatial profile, the MEM was applied not only to the spatial profile but also to wavelength profiles. This double

assumption, causes a significant reduction of reconstruction error, especially around the edge regions whose S/N are low. The measured spectrums are obtained by integrating the local line spectrum with the Gausian profiles over the viewing lines, as shown in the following equations:

$$\tilde{f}(y,k) = 2\sum_{r_i=y}^{r_i=R} a_{0i}\exp\{-\frac{k^2}{a_{2i}}\}\frac{r_i\delta r}{\sqrt{r_i^2 - y^2}},$$

$$L = \sum_{i=1}^{M}\sum_{k} g_{ik}\log g_{ik} + \gamma\sum_{i=1}^{M}\sum_{k}(f_{ik} - \tilde{f}_{ik})^2,$$

$$(g_{ik} = a_{0i}\exp\{-\frac{k^2}{a_{2i}}\})$$

where M and N are number of radial positions for reconstruction, an number of measurement channels, respectively. We determined the parameters λ, a_0, a_0, a_2 (i=1 · · ·M) by minimizing the L parameter mentioned above. The Akaike parameter was used for optimization of those parameters that strongly depend on γ parameter. Figures 1 (a) and (b) show the radial profiles of light emmisivity and ion temperature: the assumed profiles, profiles reconstructed by the conventional Abel inversion and profiles reconstructed by the new method mentioned above. The 10% and 20% noise components were added to the signals in cases (a) and (b), respectively. These data indicates that the new method is more robust against the noise component, especially in case (b).

References
[1] A. Balandin and Y. Ono, J. Comp. Phys., **202**, (2005), 52.
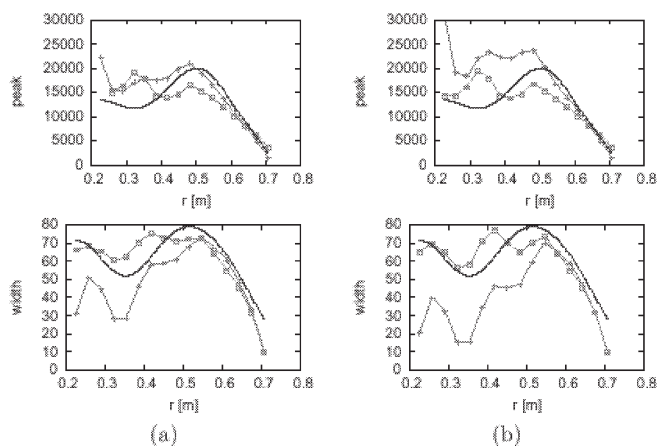[2] Y. Ono et al., Fusion Energy 2004, IC/P6-44, (2005).

Fig. 1 Radial profiles of light emmisivity and ion temperature : assumed profiles, reconstructed profiles by the conventional Abel inversion (+) and the new inversion method (∗). The 10% and 20% noise components were added to the signals in cases (a), and (b), respectively.